REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*: 02/19/2004

2. REPORT TYPE: FINAL

3. DATES COVERED *(From - To)*: 2002-2003

4. TITLE AND SUBTITLE

Interdisciplinary Research Programs in Geophysical Fluid Dynamics

5a. CONTRACT NUMBER

5b. GRANT NUMBER

Award N00014-97-1-0934

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

13093401

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Office of Naval Research
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800 North Quincy Street
Arlington, VA 22217-5660

10. SPONSOR/MONITOR'S ACRONYM(S)

ONR

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

UNLIMITED

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The Geophysics Fluid Dynamics (GFD) program consists of a summer study school of ten weeks duration each summer. The primary aim of the program is to visit a different specific area of GFD each summer, review fundamentals, and to help each other to conduct original research. Participants are approximately ten graduate student fellows, visiting graduate students and both visiting and returning scientists. The first two weeks consist of principal lectures in the summer's topic conducted by an expert in that area. Lectures by staff and visitors follow at a rate of roughly one or two per day for the next six weeks. In the last week, the fellows present results of a project and a written report. The fellows also write up the principal lectures. All are collected in a volume and on the web.

15. SUBJECT TERMS

Fluid mechanics; physical oceanography; geophysics

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
UNCLASSIFIED			UNLIMITED	4	John A. Whitehead
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Final Report 2002-2003

Interdisciplinary Research Programs in Geophysical Fluid Dynamics

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LONG-TERM GOALS

The long term goals are to train new scientists to conduct research, and to enhance the abilities of experienced research workers in geophysical fluid dynamics.

OBJECTIVES

To help graduate students formulate and tackle innovative research problems in GFD. To promote an exchange of knowledge and ideas between investigators in the different scientific disciplines that deal with the dynamics of stratified fluids, rotating fluids, fluid with phase changes and non-Newtonian fluids. To formulate tractable, important problems which are presently at the fringe of our understanding in the field of Geophysical Fluid Dynamics. To serve as a clearing-house for the mathematical, experimental and computational techniques which serve astrophysics, climate science, geodynamics, meteorology and oceanography.

APPROACH

We conduct a summer study school of ten weeks duration each summer. The participants are graduate student fellows, visiting graduate students and visiting scientists. The first two weeks consist of principal lectures in the summer's topic conducted by an expert in that area. Lectures by associated participants follow at a rate of roughly one or two per day for the remaining weeks except for the last week, when student fellows present their results. Approximately ten graduate students are admitted as Fellows. Each Fellow receives a stipend for the full ten weeks, conducts a research project under the guidance of the staff and provides a written project report. The fellows also write up the principal lectures. Several other graduate students visit for shorter periods to listen to lectures and interact with the staff. The staff (i.e. all of the visiting scientists) is continually renewed throughout the summer, although there is a core faculty who remain for the entire summer. Most of these participants receive partial travel support from the program. The lecture notes and the written report of the fellows' projects are contained in a volume that is be distributed in print form and put on the Web.

WORK COMPLETED

In 2002, the effects of bounds on turbulent transport was introduced in a series of five lectures by F. H. Busse. Although the technique has classical roots it owes its modern origins to studies of convection decades ago at the GFD program. These solutions share many properties, such as temperature profiles or shear flow profiles, with actually realized turbulent velocity fields, as illustrated by the Howard-Busse approach to this problem. In recent years the Doering-Constantin approach to the bounding problem has been developed and the equivalence of the two approaches has been demonstrated. These and several other advances have derived improved bounds on turbulent transports in recent years through the use of additional constraints and through the introduction of computational methods. These were reported in lectures by P Constantine, R. Kerswell, L Howard, C. Caulfield and C. Doering.

This more theoretical topic was complemented with a mini symposium on rotating convection in early July, which included presentations of experimental, ocean atmospheric and planetary observations. They share common features with the variational problems such as sequences of successive bifurcations and multiplicities of states.

During the rest of the program, participants and visitors who have studied turbulence, convection, and instability in numerous geophysical situations with application to the ocean, the earth's atmosphere and planetary circulation made numerous contributions with approximately 40 additional lectures.

The ten fellows selected this year were selected from a pool of applicants who are graduate students from many disciplines in their second to forth year. There was high international interest in the topic covered this summer. The fellows, their affiliation, and their report titles this year were:

Jennifer Siggers, University of Cambridge, UK "Bounds for Horizontal Convection"

Radostin Simitev, University of Bayreuth, GERMANY "Inertia Wave Convection in Rotating Spherical Fluid Shells"

Lu Lu, University of Michigan "Upper Bounds for Convection in an Internally Heated Fluid Layer"

Ulrike Riemenschneider, University of Southampton, UK "Ball Release Experiment in a Centrifuge"

Huiqun Wang, California Institute of Technology "Rearrangement of Annular Rings of High Vorticity"

Francois Petrelis, Ecole Normale Superieure de Paris, FRANCE "Bounds in MHD Tubulence I Tearing Models"

Alexandros Alexakis, University of Chicago "Bounds in MHD Tubulence II Magnetic Couette Flow and Hartmann Flow"

Tomoki Tozuka, University of Tokyo, JAPAN "On the Cyclic and Oscillatory Covections in a Simplified Box Model With Entrainment"

Evstati Evstatiev, The University of Texas, Austin "Boundary Layer Theory for the Fixed Heat Flux Problem"

Stephen Plasting, University of Bristol, UK "Infinite Prandtl Number Convection: Bound to Disprove"

In 2003, the theme was Non-Newtonian Flows. The lectures were given by John Hinch of the University of Cambridge. During the rest of the program, participants and visitors who have studied turbulence, convection, and instability in numerous geophysical situations with application to the ocean, the earth's atmosphere and planetary circulation made numerous contributions with approximately 40 additional lectures.

The nine fellows selected this year were selected from a pool of applicants who are graduate students from many disciplines in their second to forth year.

The fellows, their main interest, and their University affiliation were:

1. Alison Rust, geologist from the University of Oregon.
2. Junjun Liu, a planetary dynamicist from Caltech.
3. Joel Miller, an applied mathematician from the Department of Applied Mathematics and Theoretical Physics, University of Cambridge.
4. Christopher Wolfe, an oceanographer from Oregon State University.
5. Andrew Thompson, an oceanographer from Scripps Institute of Oceanography, U. C. San Diego.
6. Amit Apte a physicist from the University of Texas, Austin.
7. Neil Burrell, an applied mathematician from the University of Colorado.
8. Anshuman Roy, a chemical engineer from the University of Michigan.
9. Julia Mullarney, a fluid dynamicist from the Australican National Universitu

A number of features, such as a list of past fellows, the titles of the lectures, a list of participating scientists, and recent past volumes, are listed on the web at http://www.whoi.edu/gfd. Eric Chassignet, Glenn Flierl and Jean-Luc Thiffeault must be thanked for their important contributions to overseeing the computer facilities.

RESULTS

The principal lectures and fellows' reports are the tangible results. They are available as a technical report and on the web

IMPACT/APPLICATIONS

The experiences of the fellows and the staff are difficult to quantify. Many express their enthusiasm at the end of each summer. We conducted a survey two years ago for the past 20 years of fellows as part of the celebration of the 40^{th} year of the program. About 80% of the remarks were highly complimentary. Some fellows had serious suggestions for improvement. A few of the roughly 50 responses are given here:

"I benefited a lot from the school. And overall the experience was invaluable. My criticism was that I sometimes felt that the emphasis was too heavily based on getting results (namely graphs of numerical simulations) rather than education. I found this a little bit stifling because I had open-ended ideas that I wanted to explore. And I know that the help of the staff in developing these ideas with would have been very educationally valuable to me. But, towards the end I was strongly encouraged to do things that I already knew how to do, which had less educational benefit to me."

"The GFD program is a great educational experience which introduces many talented future scientists to our field. We should make every effort to make sure it continues for many generations of new scientists. Adding more visiting lecturers can be beneficial to all."

"The GFD faculty was, taken as a group, as good as or better than the best department anywhere. It was a real treat to be a student/fellow of this group."

"The most valuable lesson for me was watching this accomplished group 'do science'. I learned more from interacting with them, and watching/listening to them interact with one another and with other fellows than from any specific problem or piece of research."

"I chose the wrong project with the wrong advisor. I didn't get much out of the summer. But, in a different situation, I definitely would have."

The Dean's office also has the fellows evaluate the program, and many comments are similar to those given here.

TRANSITIONS

We estimate that typically 20-50% of the student projects become included in their thesis or postdoctoral work and/or result in publications. The program does not follow the fellows' research after the summer is finished although individual staff members often remain involved with the fellows' continuation of their projects past the end of the summer.

RELATED PROJECTS

All staff members are active research workers, so numerous related projects exist.